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Creating the next Generation of E-Assessments in the Real World

Rob Byatt, Centre for Evaluation and Monitoring, Durham University

Abstract

With the technologies and analysis models available to us, there are an ever increasing number of ways we can deliver e-assessments. However, when trying to deliver reliable, innovative and rich e-assessments in the real world a number of technical challenges quickly appear. This paper looks at some of those challenges and how we can overcome them.

Keywords

E-assessment; assessment; web; rich-media; schools; multi-platform

Introduction

Durham University's Centre for Evaluation and Monitoring (CEM) has been delivering assessments to schools for 30 years. These were initially delivered as paper tests and from the mid-1990's they began to be delivered electronically. Today the vast majority of the assessments (approaching 90% of CEM's total number of assessments) are delivered electronically to over 1 million children and young people every year. The vast majority of these electronic assessments are adaptive. Adaptive means that the questions a candidate receives are tailored to their ability. CEM assessments estimate pupils' abilities, attainment and attitudes with the aim of providing teachers with information that can be used to both inform learning and monitor progress. Areas covered include reading, maths, and developed ability (a composite measure including vocabulary acquisition and non-verbal reasoning, which gives an indication of the pupil's context). The assessments are delivered in a consistent and standardised fashion to ensure fair comparisons can be made over time and across cohorts.

Good quality assessments are reliable and valid: they measure what they set out to measure consistently. In order to do this with electronic assessments there are particular approaches that can be taken. For example, in one of our mathematics assessments, which is targeted at children aged 6 – 11 years, questions are presented on-screen but they are also presented aurally to avoid confusing the requirement to be able to read with the ability to solve mathematical problems. The child can also choose to repeat the audio if they wish because it is sometimes difficult to retain and process the information presented in more complex maths questions. The audio should be of high quality to avoid discriminating against any candidates with hearing impairments (Knight and Swanwick 1999).

Particularly when assessing younger children, including audio within the assessment can be vital to make sure an assessment is accessible and is assessing what it should do. Combining the audio with high quality graphics results in rich, multi-media assessments.

However, delivering media rich, high quality e-assessments, that measure what they set out to measure, that are adaptive, reliable and deliver consistently across school

infrastructure, so that the assessment is standardised poses a number of challenges. Some of these challenges are specific to delivering assessments in schools and some are more general. The following is based on analysis of industry surveys of school ICT provision and technology trends along with the experiences of CEM staff administering e-assessments within schools.

School IT infrastructure

The British Educational Suppliers Association (BESA) provides valuable insight into the current provision of ICT in UK state schools (BESA 2012). Table 1 summarises some of their findings that can lead to problems deploying and running software from schools.

Table 1: Summary of BESA Survey ICT Provision Survey (Based on a sample representative of 22405 state primary schools and 4290 state secondary schools as of April 2012)

	Primary Schools	Secondary Schools
Average number of computers per school	49.1	325.2
<i>In relation to the averages above:</i>		
Computers over 5 years old	13.2	77
% of all computers over 5 years old	26.88%	23.68%
Computers that regularly use Wi-Fi	16.5	101
% of all computers that regularly use Wi-Fi	33.60%	31.06%
Computers using Windows 7	21.7	130.4
% of computers using Windows 7	44.20%	40.10%
The number of computers that would be considered optimal	81.7	428.6
Current % of optimal level	60.10%	75.87%
Number of computers considered ineffective by staff	8.4	57.9
% of computers considered ineffective by staff	17.11%	17.80%
Average broadband bandwidth per school	13.2 Mbps	42.5 Mbps
Ideal broadband bandwidth per school	32.5 Mbps	71.7 Mbps

Source: BESA ICT in UK State Schools 2012

Several of these findings potentially impact the successful deployment and consistent, reliable running of software on schools' ICT infrastructure.

Age of school ICT provision

Around a quarter of UK State schools' computers are over 5 years old. This means that these computers are past their predicted life span. Their processors and memory provision are unlikely to be of sufficient scale to run modern software. They may be running old operating systems and other software that has not been updated for some time. These factors can lead to significant compatibility issues with newly developed software that is developed using tools that presume a certain level of modernity in the firmware and software it interacts with.

Thus, new, rich media e-assessments are more likely to hit difficulties when it is run on old technology. Processors and computer memory may not be sufficiently quick enough and large enough to run the assessment software. If web browser versions are several years old and do not contain recent software updates or up-to-date browser plug-ins, assessment software delivered over the web may not run at all. If it does run, it may not run the same way it was intended to. For example, graphical parts of assessment items may appear differently on old browsers or not even appear at all. Thus the standardised nature of the test is then being compromised. Equally a slower, older computer may lead to the slow running of e-assessment software. For example a large audio and graphic library may take a while to load on a slower computer leading to a delay part way through an assessment. As the candidate sitting an assessment has now been given an interval, the standardised nature of the test is being compromised.

Based on the experience of CEM staff, computer peripherals used in schools are often old and in a poor state of repair. Monitors with washed out colours, keyboards with keys that do not work, mice that are difficult to use and speakers or headphones that vastly reduce audio quality are all issues that have been encountered. Candidates sitting e-assessments with modern, high quality computer peripherals could be argued to be gaining advantage over those sitting e-assessments delivered using obsolete or broken peripherals.

Web connectivity

Many of us take good quality web connectivity at home, at work and even when travelling for granted. As of February 2013 Virgin Media's basic broadband package for domestic customers boasts a speed of 30Mbps¹ (independently validated to be a typical available speed of 30.17Mbps). Their top package offers a transfer speed of 100Mbps (validated to be a typical available speed of 92.14Mbps). The typical broadband speed of a UK state primary school is 13.2Mbps. For a secondary school it is 42.5Mbps (BESA, 2012).

There are numerous demands on schools' connections to the internet. So when a school comes to run an e-assessment that requires web access, it is potentially on a busy network that has a slow connection speed compared to the expected business and domestic standards of today.

There are many advantages to e-assessments that connect over the web or are even run via a browser compared to e-assessments locally installed on a school's network.

As per most software, if e-assessment software can be delivered as a web application, using a browser then the deployment and distribution of it is much simpler and easier than when it has to be installed at every school that uses it. It simply requires an installation on a web server and schools can then connect to the software using a web browser by entering the correct web address. This is particularly appealing to the many schools who have contracts with their ICT support provider whereby they can be charged for every software install they do. CEM recently heard of additional software instalment costing a school as much as £500.

¹ <http://store.virginmedia.com/broadband/speeds-explained/our-typical-speeds.html>

Thus delivering e-assessments over the web, where the location of the assessment only has to be saved as a browser bookmark can save schools a considerable amount of money and reduce a barrier to e-assessment.

A web enabled e-assessment also allows assessment results to be automatically passed onto systems that need them in a quick and hassle free manner reducing the need for manual intervention from teachers.

Wi-Fi allows greater flexibility for connecting to networks including the web. It means computers can be more effectively used in parts of schools that don't have physical networks. This can be of great convenience to teachers and provides pupils with a resource they would not otherwise have. However, when running e-assessments it can result in problems. The issues running media-rich e-assessments over the web is exacerbated when Wi-Fi connectivity is involved. Wi-Fi networks are less reliable and slower than the physical networks they connect to. Almost a third of computers in schools are set up to use Wi-Fi (BESA 2102). CEM has experienced several instances of whole classes sitting e-assessments simultaneously, whilst relying on a single Wi-Fi router for network connectivity. The typical specification of Wi-Fi found in schools is simply not able to or not configured to handle a class of 30 using it simultaneously. This can result in assessment software not loading on computers as it tries to pull media files across a network and the results of assessments not being transferred successfully.

E-assessments of children of primary school age benefit from audio instructions and audio accompanying the assessment items being presented. To be effective this audio has to be clear. This means the electronic audio files need to contain high quality audio and thus need to be large in size. For example a single section of CEM's assessment for primary schools has audio files of around 25MB associated with it. As the BESA survey figures show, there are slow web connection speeds in primary schools and extensive use of Wi-Fi. This does not make it easy to deliver e-assessments containing audio across the web or potentially even across a school's network.

Trialling in Schools

CEM has recently trialled delivery over the web of a maths assessment for primary school children that have 25MB of audio files associated with it. The primary school in question had a reasonably up to date ICT suite with 30 desktop PCs connecting to the web physically with an available download speed of almost 30Mbps. This is a significantly higher connection speed than the average for primary schools quoted by BESA 2012 of 13.2Mbps.

We tried 2 different methods for downloading the audio with a class of 30 year 6 pupils (10-11 year olds). Both, full download at the start of the assessment, and intermittent downloading of the audio in chunks throughout the course of the assessment were tried. The trial produced mixed results, highlighting the challenges we face when delivering rich e-assessments across the web.

Downloading the media files at the start of the assessment proved to be partially successful. All the class that attempted this method managed to download the files and thus were able to carry out the assessment. However several pupils had to retry

once before the assessment could start successfully. The more the pupils simultaneously tried to launch the assessment, the slower the download was and hence the more time it took for the assessment to start. Delays of over a minute to start the assessment were encountered by some.

The method of downloading the audio in parts throughout the assessment was also partially successful. The assessments were completed successfully by the pupils running software using this method but the issues encountered were deemed to be unacceptable for delivering a standardised test. Initially this method seemed to have the assessments running smoothly with audio being available for its corresponding assessment items. However part way through the assessment, audio files were not being downloaded in a timely manner and the assessment software had to pause the assessment until audio associated with the next set of questions was available. Pupils had to wait for around a minute in the middle of a 20 minute assessment whilst the next questions loaded. This was considered serious as it was potentially breaking the standardised delivery of the assessment. If the problem had been much worse it could have resulted in partially completed assessments being terminated and the time already spent on the assessment by the pupils would have been of no use.

Our experience was deemed to show us that downloading the media for a web delivered-e-assessment at the start of the assessment was the best way forward. If the assessment media failed to load at the start, the class had wasted less time than if they had already sat a good part of an assessment and it then failed. The delays to the assessment that could occur intermittently throughout the course of the assessment, when the audio was downloaded bit by bit, were deemed to be breaking the standardised delivery. However both methods show that delivery over the web has its problems.

Proliferation of devices, operating systems and browsers

Microsoft has enjoyed predominance for many years with its Windows operating systems and Internet Explorer web browsers enjoying hugely dominant market positions.

It still commands a large share of operating system usage but this is being reduced on a consistent basis (see Figure 1 below). The popularity of Android and iOS tablets and mobile devices will continue to eat into Microsoft's share of the OS market. Technology researchers Gartner predict that Android will be used on more devices than Windows by 2016 (Gartner 2012).

The proportion of browsers being used that were versions of Internet Explorer (IE) reached as high as 95% with usage of IE6 peaking at the high 80s% in 2002 and 2003 (OneStat 2008). Since then the market share of IE has declined markedly. First Mozilla Firefox and then Google Chrome have taken away large portions of its market share. As Figure 2 below shows the most popular web browser today (Google Chrome) now only accounts for around a third of total usage.

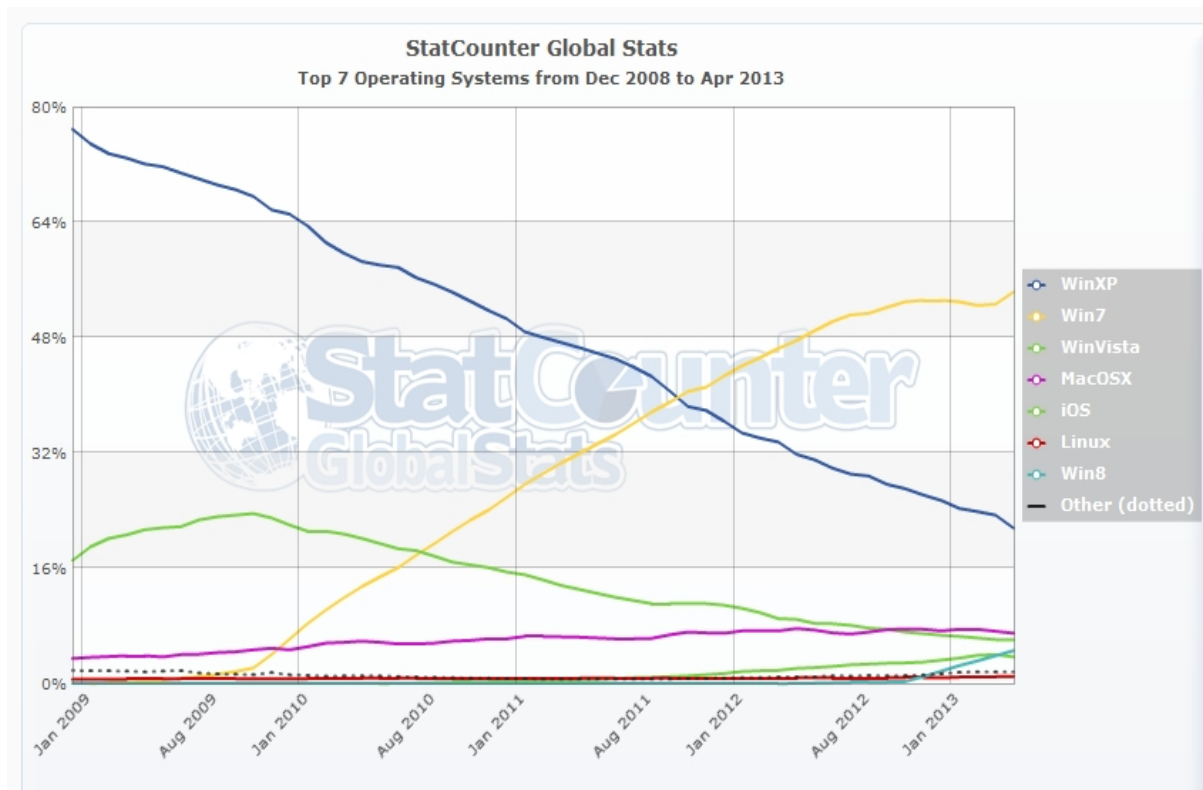


Figure 1: Global Trends in Operating Systems ([statcounter](http://statcounter.com))

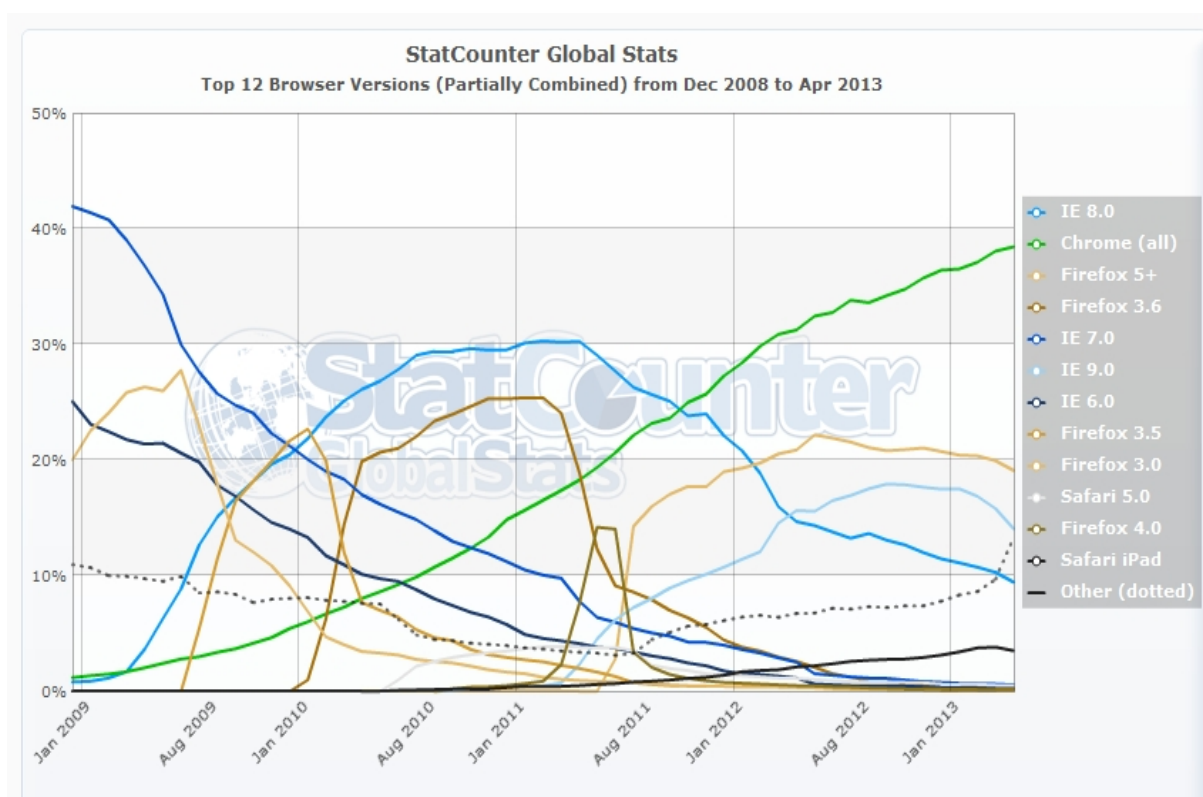


Figure 2: Global Trends in Web Browsers Used ([statcounter](http://statcounter.com))

As well as operating systems and browsers, the devices running them have also proliferated. Along with traditional Microsoft Windows and Apple Mac desktops and laptops there are netbooks, and a huge growth in tablets and smart phones being used.

Whilst competition and choice in this area is useful for consumers it provides a significant challenge for software providers hoping to deliver across multiple platforms. Reflective of these trends, schools are beginning to use a range of devices, operating systems and web browsers. Therefore the e-assessments CEM delivers have operate in an equivalent and standardised fashion across a number of platforms. It is impractical to have a different approach to each device. An approach that is not quite one-size fits all, but does take account of the different requirements of different platforms is needed. This is a problem affecting all software providers and is well summed up by the issues the BBC has getting their popular iPlayer service working across different devices (BBC 2012a).

Some organisations negate the issue of having to deal with different devices, operating systems, and software by standardising many or most of the computers they use. The UK Government Department of Work and Pensions (DWP) have around 140,000 desktop users in over 1000 locations (King 2012). In order to bypass many of the issues outlined above their computer suppliers deliver a standard hardware specification with a standard operating system and software build. Whenever new software is added to this standard build (for example a new version of a web browser), it is extensively tested with the other software it will interact with and on the platform it will sit, prior to being fully released.

Another reason for difficulties in delivering rich e-assessment across the web to schools is the archaic nature of the web browsers still used by some schools. According the web stats on the cem.org website around 3% of its traffic is from IE6, a web browser initially introduced in 2001. 8% is from IE7, initially introduced in 2006.

An Australian online retailer has even taken to making an additional charge to those who access its website with IE7. They justify doing this because of the extra adaptations they have to make to their website in order for it to display properly with IE7 (BBC 2012b).

One of the problems delivering e-assessments via older web browsers is that they may not render graphics in the same way a more modern web browser would. All browsers can render HTML differently but this problem is more pronounced in old browsers, particularly with the functionality now available in HTML5 (Google 2012). Equally e-assessments that are developed using Adobe Flash technology and rely on a Flash Player plugin within a browser may have problems running in older browsers due to compatibility issues between the browser and plug-in software.

These types of problems can be particularly serious when delivering adaptive, standardised e-assessments. If assessment items do not display or do not display properly, then candidates may answer them incorrectly. If this happens once in an assessment it may not significantly affect the score, but if it happens regularly, the assessment is no longer standardised and the candidate is likely to have an invalid score that does not reflect their real ability.

Devices and platforms have proliferated over the last few years creating a challenging environment for delivering software in general and e-assessments across all the available options. Whilst it is challenging now, the level of proliferation could easily continue to rise significantly. Microsoft Windows 8 is facing a slow adoption rate (3.1% of the PC market after 5 months - Windows 7 had a 10.5% share after the same period), (NetMarketShare 2013). This has further undermined Microsoft's earlier dominance of the computer operating system market. More changes could be driven from the far-east. Chinese, Korean and Taiwanese companies manufacture the majority of the world's PCs, smartphones and tablet computers. These devices are dependent on operating systems (Microsoft Windows, Apple Mac OS and iOS and Google Android) that are controlled by western companies. The Chinese government is concerned about this and has encouraged Alibaba, China's biggest e-commerce company, to create its own operating system. The firm has set up a one billion Yuan (£105m) programme to encourage app developers (BBC 2013). We are used to technological trends being started in western economies, particularly the USA. However, as more economic power begins to reside in fast growing economies such as China and India, it is likely they will begin to drive future changes, perhaps leading to further proliferation of devices, operating systems and software as the dominance of Apple, Google and Microsoft is challenged.

Approaches to cope with these challenges

It is impractical to have a different approach to developing e-assessment software for each device or platform. Equally the proliferation of devices, operating systems and web browsers used by consumers of e-assessments cannot be ignored and a one size fits all approach will not suffice.

This means a number of things on a practical, software development level. The core parts of the e-assessments – the actual questions, adaptive algorithms and the framework in which they sit need to remain standard across platforms. This is particularly important when we wish to compare results of those sitting our e-assessments across different platforms and we wish to deliver a standardised test. Thus we cannot and should not develop a different assessment for each platform. This means we have to look at clever ways of packaging and deploying e-assessments so that they run in a standard manner no matter what the platform. There is development software that helps us do this, such as [Adobe AIR](#) and [Zinc](#). We can also make parts of the e-assessment configurable for particular platforms and environments and produce platform specific libraries. This can also be very useful when delivering e-assessments in different languages or even using different alphabets such as Arabic and Chinese.

We need to test the e-assessment software on different platforms and different combinations of devices, operating systems and web browsers. This can be done with in house virtual machines running multiple combinations of software or using websites such as [browserstack](#). We also need to trial in schools and the organisations running our software. This can create scenarios that we would not have thought to test in house.

We may need to make compromises in the software we deliver. As technologists we may like the idea of using the latest technology to deliver an e-assessment, but if school's infrastructure cannot cope with it, then we should reconsider. We can also deliver our e-assessments by more than one mechanism. Some schools' infrastructure may be able to support running a web browser version and some may not. We should consider delivering web based and locally run versions of the same assessments.

Delivering e-assessments across a multitude of platforms is challenging. ICT provision in schools can be outdated, and the technologies required to interact with is changing and growing in number. However with some consideration and following the approaches outlined above we are still able to deliver high quality, media rich, adaptive, standardised assessments that work reliably across platforms and give value to our customers.

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